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Final Report

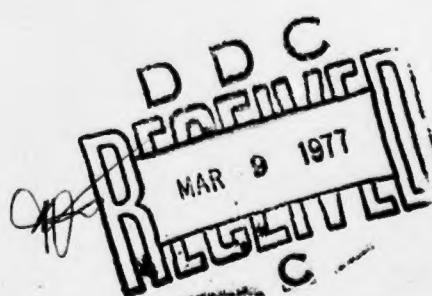
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Wave Propagation, the Dynamics of Elastic Structures
and Stability, and Neutron Transport

Prepared for

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Edward L. Reiss
Project Director

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A total of nine investigators completed 32 research projects yielding 22 publications, 10 accepted or submitted, and 5 in preparation. Subject areas were structural analysis (12), wave propagation (13), fluid dynamics (5), and transport theory (5). Topics included higher order buckling in the presence of imperfections, dynamic instability, composite material, wave propagation through nonlinear and random media, vortex motion in fluids, the small mean free path approximation to the transport equations, etc. Asymptotic, perturbation and bifurcation techniques predominated. The application of the techniques of		

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20 Abstract

stretching and matching from asymptotic theory to bifurcation problems might be considered a breakthrough, funded by AFOSR, ONR and ARO, with applications in buckling, flutter, flame stability, etc.

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discovering how well asymptotic methods fit certain situations
S1001. How well they work in various situations
and what difficulties to expect when using them
in particular, the need

for

OPTIMALITY

minimum displacement under given boundary

and other aspects can be developed and discussed and be listed. A general discussion of some of these, relating to deformations and displacements, will be given, and some of the existing terms and even some new ones will be defined and might be used. The results presented will be both theoretical and numerical, including pictures and conclusions. The main point will be to relate and compare different methods, especially those based on asymptotic theory, with more standard methods and to find out what is best for what purpose.

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During the past 5 years in which we worked on this contract, 32 research projects were completed. This resulted in 22 publications, and 10 papers which have either been accepted for publication or submitted for publication. In addition, there are several other papers in preparation. All of these publications are listed in Appendix A of this report.

Aircraft and missile structures are subjected to a variety of static and dynamic loads when in flight. As a result, the structure or components of it, may buckle or respond non-linearly in other ways. The responses of the structure, and their interactions with the air, are described by boundary and initial value problems for ordinary and partial differential equations. We have analyzed a variety of these problems by using asymptotic and perturbation methods, and methods of bifurcation theory. We have developed new methods and applied them to solve specific problems. These are described in reports AFH 5, 17, 23-26, 33, 34, 36, and 37. The main results consist of: new methods for analyzing buckling (bifurcation) in the presence of imperfections; a new perturbation method for analyzing secondary transitions; and a new method for calculating the transient motions of dynamic instability.

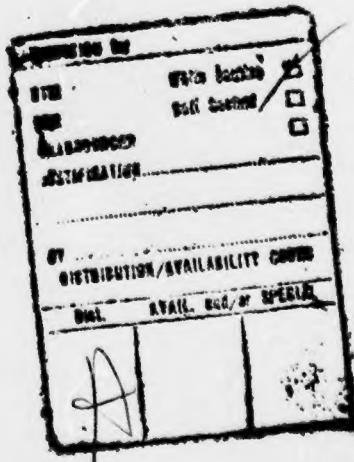
In addition, we studied the transient motion of waves and pulses through air, and other gases, and through solid structures. These motions can be caused by phenomena such as explosions, the passage of aircraft or missiles through sonic speed, maneuvers and other motions of aircraft. Appropriate

asymptotic and perturbation methods were developed or applied to specific problems. This led to reports AFH 3, 9, 10, 11, 14, 20, 27, and 35. The development of new mathematical techniques for analyzing wave propagation in a variety of random media are considered in AFH 1, 2, 6, 7, and 8.

Other investigations were concerned with vortex motion of fluids, AFH 19 and 28. Other problems in fluid dynamics are treated in AFH 29, 31, and 32. The elasticity of composite media was studied in AFH-13, while AFH-12 contains a new method for analyzing contact problems in elasticity.

Finally, new asymptotic methods were developed and applied in AFH 15, 16, 18, 21, and 22 for treating neutron transport and diffusion problems.

The common feature of most of this work is asymptotic and perturbation analysis. The techniques which have been useful in solving the particular problems of this project are of interest, and applicable to many other problems.



AFH Reports and Publications

- AFH-1** I. Besieris Reciprocity Relations for Uniformly Moving Magnetoelectric Media
Pub: Proceedings of the IEEE, 60, 2, (1972)
 pp. 229-230.
- AFH-2** I. Besieris Stochastic Master Equations: A Perturbative Approach
Pub: J. Math. Phys., 13, 3, (1972), pp. 358-360.
- AFH-3** B. Seymour Resonant Acoustic Oscillations with Damping;
 M. Mortell Small Rate Theory
Pub: J. Fluid Mech., 58, Part 2 (1973)
 pp. 353-373.
- AFH-4** B. Nicolaenko The Spectral Theory of Linearized Special Relativistic Model Boltzmann Equations
 J. K. Thurber
Acc: Proceedings of the Rarefied Gas Symposium
- AFH-5** A. Callegari Nonlinear Stability Problems for the Sine-Gordon Equation
 E. Reiss
Pub: J. Math. Physics, 14, 2, (1973) pp. 267-276.
- AFH-6** I. Besieris Kinetic Equations for the Quantized Motion of a Particle in a Randomly Perturbed Potential Field
 F. D. Tappert
Pub: J. Math. Physics, 14, 12, (1973) pp. 1829-1836.
- AFH-7** I. Besieris Wave Packet Spreading on a Random Transmission Line
 F. D. Tappert
Pub: J. Applied Physics, 44, 5, (1973) pp. 2119-2121.
- AFH-8** I. Besieris Propagation of Frequency Modulated Pulses in a Randomly Stratified Plasma
 F. D. Tappert
Pub: J. Math. Physics, 14, 6, (1973) pp. 704-707.
- AFH-9** D. S. Ahluwalia Elastic Waves Produced by Surface Displacements
 J. B. Keller
 R. Jarvis
Pub: SIAM J. Appl. Math., 26, 1, (1974) pp. 108-119.
- AFH-10** D. S. Ahluwalia Uniform Asymptotic Solution of Eigenvalue Problems for Convex Plane Domains
 J. B. Keller
Pub: SIAM J. Appl. Math., 25, 4 (1973) pp. 583-591.

- AFH-11 D. S. Ahluwalia
J. B. Keller
B. Matkowsky Asymptotic Theory of Propagation
in Curved and Nonuniform Waveguides
Pub: J. Acoustical Soc. Amer., 55
(1974), pp. 7-12.
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J. B. Keller Contact of Inflated Membranes with
Rigid Surfaces
Pub: J. Appl. Mech., 41, 1, (1974),
pp. 189-191.
- AFH-13 J. B. Keller
J. Flaherty Elastic Behavior of Composite Media
Pub: CPAM, XXVI (1973) pp. 565-580.
- AFH-14 J. B. Keller
J. Rosenfeld Wave Propagation in Elastic Rods
of Arbitrary Cross Section
Pub: J. Acoustical Soc. Amer., 55, 3,
(1974), pp. 555-561.
- AFH-15 J. B. Keller
E. Larsen Asymptotic Solution of Neutron Transport
Problems for Small Mean Free Paths
Pub: J. Math. Phys., 15, 1 (1974)
pp. 75-81.
- AFH-16 E. Larsen
P.F. Zweifel On the Spectrum of the Linear Transport
Operator
Pub: J. Math. Phys., 15, 11 (1974) pp. 1987-
1997
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E. L. Reiss
L. Bauer On the Collapse of Shallow Membranes
Pub: Nonlinear Elasticity, Academic
Press, 1973, pp. 1-30.
- AFH-18 E. Larsen Solution of Neutron Transport Problems
in L_1
Pub: J. Math. Anal. & Applics., 28
(1975) pp. 729-746.
- AFH-19 J. Norbury Steady Vortex Pairs in an Ideal Fluid
Pub: CPAM, 28, 6, (1975) pp. 679-700.
- AFH-20 G. Rosenfeld
J. B. Keller Wave Propagation in Non-Uniform
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Pub: J. Acoustical Soc. Amer., 57, 5,
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Inhomogeneous Media I
Pub: J. Math. Phys., 16, 7, (1975)
pp. 1421-1427.

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in Inhomogeneous Media II
Pub: Nuclear Sci. and Engg.,
60 (1976), pp. 357-368.
- AFH-23 F. C. Hoppensteadt Slowly Modulated Oscillations in
D. S. Cohen Nonlinear Diffusion Processes
R. M. Miura Acc: SIAM J. Appl. Math.
- AFH-24 B. J. Matkowsky Singular Perturbations of
E. L. Reiss Bifurcations
Acc: SIAM J. Appl. Math.
- AFH-25 E. L. Reiss Imperfect Bifurcation
Acc: Adv. Seminar on Bifurcation Theory, Univ. of Wisconsin.
- AFH-26 F. C. Hoppensteadt The Transient States in the Onset
of Convection in the Benard Problem
Acc: Proc., Journees Math. sur les Perturbation Singulieres,
Springer-Verlag.
- AFH-27 A. J. Callegari On the Singular Behavior of Linear
M. K. Myers Acoustic Theory in Near-Sonic Duct Flows
Acc: J. of Sound and Vibrations.
- AFH-28 A. J. Callegari Analysis of the Motion and Decay
L. Ting of a Curved Vortex Filament
Acc: SIAM J. Appl. Math.
- AFH-29 A. J. Callegari A Nonlinear Singular Boundary
A. Nachman Value Problem in the Theory of
Power Law Fluids
Acc: SIAM J. Appl. Math.

- AFH-30 F. C. Hoppensteadt
W. L. Miranker Multi-Time Solution Methods for
Systems of Difference Equations
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- AFH-31 A. J. Callegari
A. Nachman A Nonlinear Boundary Value
Problem in Shock Wave Boundary
Layer Interaction
Sub: J. Math. Analysis and
Applications.
- AFH-32 A. J. Callegari
M. B. Friedman The Blow Off Problem—An Analytical
Study
Sub: SIAM J. Appl. Math.
- AFH-33 F. C. Hoppensteadt
S. Persek Nonlinear Stability Analysis of
Highly Oscillatory Systems with
Applications to Benard Convection
in a Rotating Frame
In preparation.
- AFH-34 E. L. Reiss
B. J. Matkowsky
L. Putnick Buckling of Imperfect, Rectangular
Plates
In preparation.
- AFH-35 E. L. Reiss On the Derivation of Linear Beam
Theory
In preparation.
- AFH-36 E. L. Reiss
B. J. Matkowsky
L. Putnick Secondary States of Rectangular
Plates
In preparation.
- AFH-37 E. L. Reiss
L. Putnick
B. J. Matkowsky Nonlinear Periodic Oscillations of
Rectangular Plates
In preparation.